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FIFTH QUARTERLY PROGRESS REPORT

PREPARED UNDER
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UNDER THE TECHNICAL SUPERVISION
OF THE ATOMICS BRANCH OF
THE APPLIED PHYSICS DIVISION
U. S. ARMY SIGNAL RESEARCH AND
DEVELOPMENT LABORATORIES
AT FORT MONMOUTH

by
M. N. HIRSH
P. N. EISNER

R-146-5

30 SEPTEMBER 1962

THE G. C. DEWEY CORPORATION

AN EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF RADIATION ON THE PROPAGATION OF ELECTROMAGNETIC SIGNALS IN AIR

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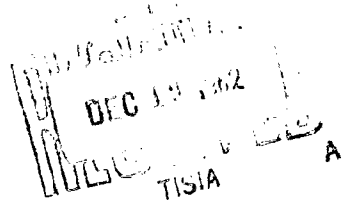

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I. INTRODUCTION

The present report covers work performed during the period 1 July to 30 September 1962. It includes a description of the present status of the equipment, and an account of a series of experiments performed during the period. The results of these experiments are discussed, and a tentative interpretation of the high pressure oxygen data is given in terms of 3-body attachment. Deviations from the simple oxygen molecule at lower pressures are discussed. In the last chapter, the plans for the next quarter are discussed.

II. EXPERIMENTS

A. Introduction

During the first half of this quarterly period, the major work was put into improving the experimental apparatus along the lines indicated in the Fourth Quarterly Report. A beam diffuser was built which has a larger diameter foil in order to eliminate the geometrical variations in the beam current due to beam position shifts. A water-cooled baffle was installed between the ultra-high vacuum pump and the zeolite trap to improve the zeolite baking procedure. The undiffused electron beam was centered on the cavity face; to increase the diffusion the beam was scattered in five Beryllium foils instead of one as before. An r-f measuring technique was developed increasing the ease and accuracy of frequency measurements. When these improvements were made, a series of measurements was made on the equilibrium ionization in air and oxygen at various pressures.

B. Vacuum

After a water cooled baffle was inserted between the zeolite and the oil diffusion pump on the ultra-high vacuum pumping stack, the zeolite could be heated to full temperature and outgassed overnight. When this was done, it was found that the pressure reached an equilibrium of 5×10^{-5} mm with the zeolite hot. However, when the zeolite cooled, the pressure did not drop appreciably. Instead a leak developed in the gold O-ring flange above the zeolite trap and the flange itself was found to be warped. Following the philosophy put forth in the Fourth Quarterly Report to develop "the whole system to a workable condition rapidly rather than perfecting any one piece of equipment", work was stopped on the vacuum system until a series of preliminary ionization experiments on air and oxygen was completed, so that the knowledge gained from these experiments could be included in the next quarter's equipment modification program. (See Chapter IV)

C. Electron Beam Diffusion and Measurement

The electron beam was located at the cavity by covering the inside back plate of the cavity with scotch tape and then bombarding the scotch tape with a 1 ma beam until a significant pressure rise on the ionization gauge indicated a burning of the tape. This took about 10 minutes. No foil separated the cavity from the beam tube for this experiment; only the beam tube diffusion pump was operating. The ionization gauge in the cavity indicated an initial beam tube pressure of 4.5×10^{-5} mm; the pressure rose to 6.7×10^{-5} mm during the bombardment.

It came as no surprise to find the beam off center, because gamma flux measurements indicated that the beam had been striking to the right of center (looking away from the Van de Graaff accelerator). The exact location of the beam was $8\frac{1}{2}$" to the right of the cavity's axis and $5\frac{1}{2}$" above the axis. By moving the Van de Graaff accelerator on its carriage this offset was corrected. The scotch tape has a decidedly non-linear response to electrons, so that the distribution of electrons across the face of the cavity could not be quantitatively measured. Visually the distribution was peaked, a dark spot about one foot in diameter, centered at the undiffused beam, being observed. Therefore, the single .004" thick Berrylium foil was replaced by five foils with a total thickness of .024". These five foils will give a diffused beam with a $2\frac{1}{4}$ foot diameter using the scotch tape as the criterion of diffusion. Scattering by additional foils would overheat the collimator, limiting the number of foils to five. Despite the lack of quantitative data on the beam distribution, further work on the beam diffusion problem was deferred until after the air and oxygen experiments were completed so that any information learned from these experiments could be incorporated into the next equipment changes.

In the Fourth Quarterly Report, it was stated that the electron beam could be calibrated using the total current meter on the

Van de Graaff console. The relationship is $I(\mu a)_{Beam} = I(\mu a)_{Total} - 75\ \mu a$. However, the console meter can only be read to an accuracy of ±10 microamperes. A more reproducible and accurate reading can be made on the beam control pentode dial, which is a ten-turn helipot with a vernier dial. This helipot controls the grid bias on the pentode in series with the cathode of the Van de Graaf electron gun. Consequently, this dial was calibrated with a Faraday cup on the beam tube before the diffuser. Figure 1 is a plot of the pentode dial reading versus the beam current entering the diffuser. As long as the beam entering the cavity can be considered a fixed fraction of the beam entering the diffuser, then to within that multiplicative constant the electron beam can be measured to ±5%.

D. Gas pressure Measurement

A capacitance manometer was used to determine the pressure of the gas in the experimental cavity. The procedure was to balance the cavity pressure against room air, at a pressure measured with an oil manometer, using the capacitance manometer as a null detector. In this way, the capacitance manometer itself was calibrated since by pumping out the oil manometer, the capacitance manometer indicated the cavity pressure. (See Figure 2)

After the electron beam measurements were taken, a new aluminum foil was put between the cavity and the beam cone. This foil was unsupported except at the edges, and consequently, bows when gas is let into the cavity, although the foil will support at least 30 mm of pressure in the cavity without rupture. Because the bowing decreases the rf resonant frequency of the cavity, the foil may be used as a pressure reading device; a plot of pressure versus the change in cavity resonant frequency is shown in Figure 3. The calibration was found to be very reproducible.

Using these two techniques, the pressure in the cavity could be measured between 0.3 mm and 10 mm with an accuracy of about ±3%. To extend the readings to lower pressures a McLeod gauge will be necessary and will be obtained for the next quarter.

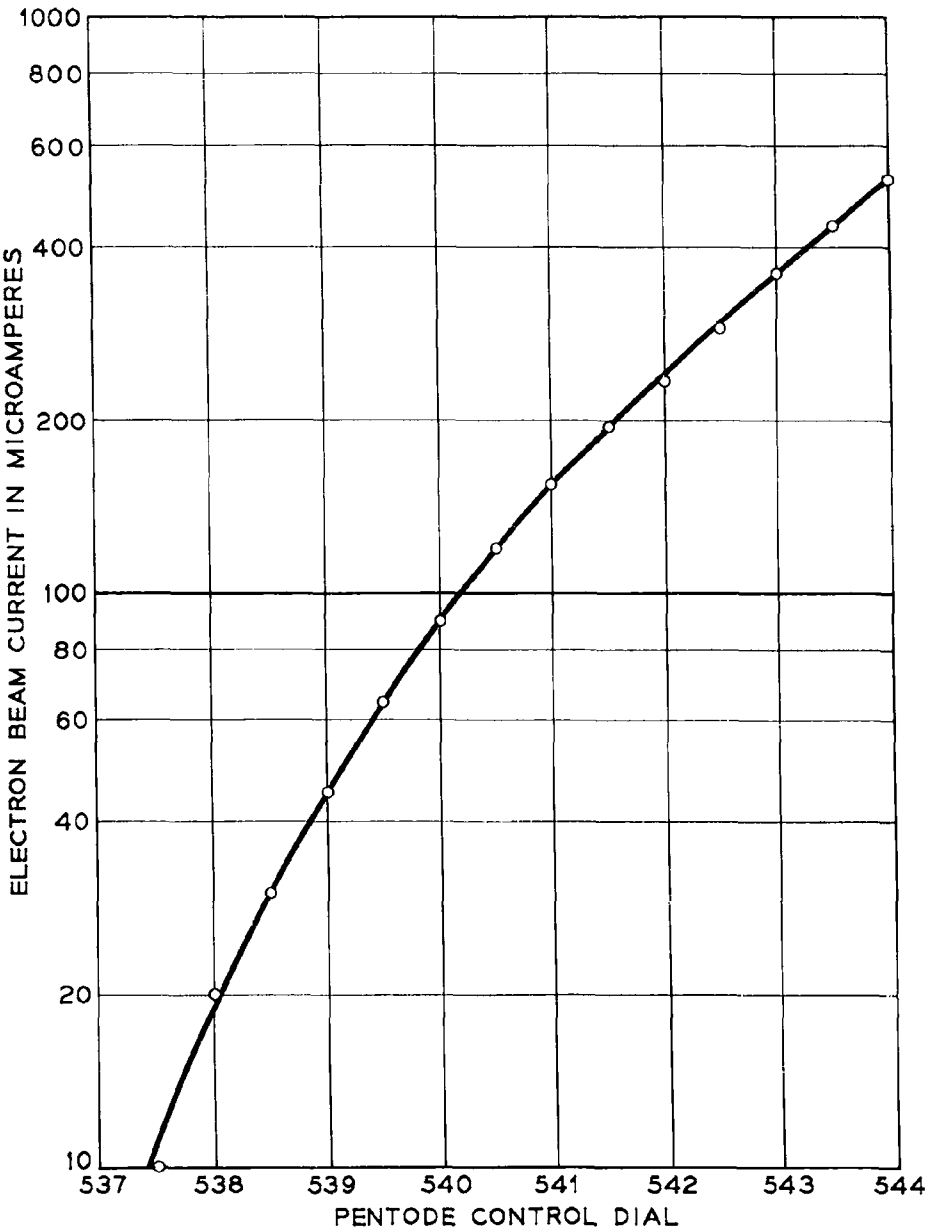

FIGURE 1
CONTROL PENTODE DIAL READING VS
ELECTRON BEAM CURRENT

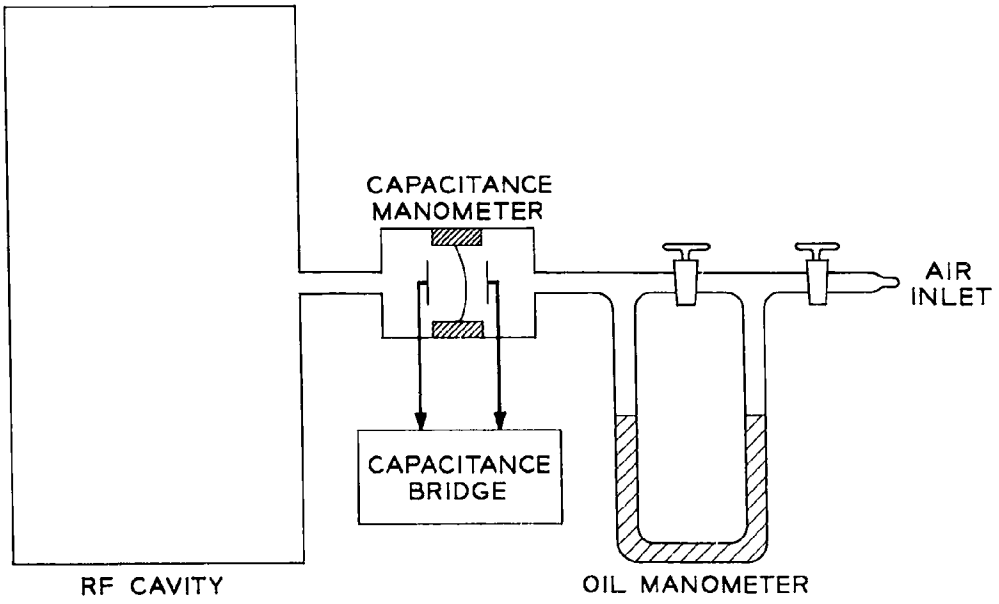

FIGURE 2
GAS PRESSURE MEASURING SYSTEM-SCHEMATIC

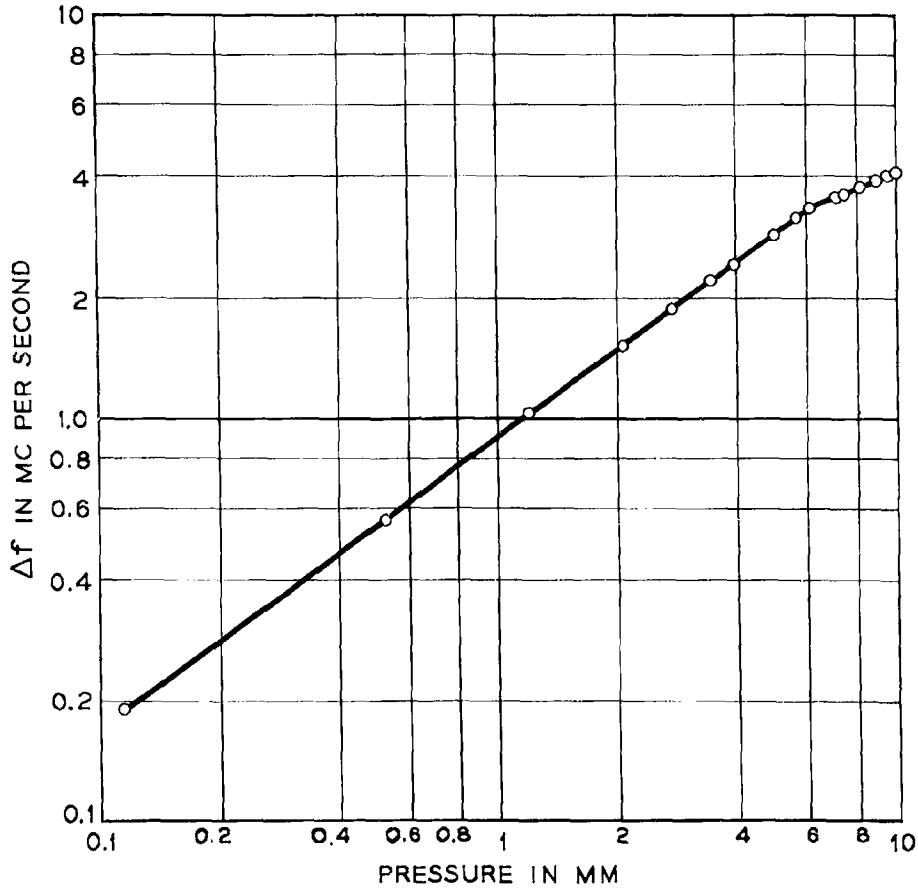

FIGURE 3
CHANGE IN CAVITY FREQUENCY VS
CAVITY GAS PRESSURE FOR UNSUPPORTED FOIL

E. RF Measurements

A further improvement has been made in the rf circuitry in order to improve the accuracy of frequency shift measurements. A scheme has been developed which will measure $\Delta\nu$ to within 1 Kcps, or n_e to 10^4 electrons/cm^3, a factor of 10 improvement over the circuit used during the fourth quarter.

The circuit is shown in Figure 4. A low frequency ($\sim$1Mc/s) oscillator signal is mixed with the main UHF oscillator signal. The sum frequency is then used as the probing signal into the experimental cavity. The lower frequency oscillator is tuned so that the sum frequency is always in resonance with the cavity. The low frequency oscillator can be read to 1 kilocycle per second, this now being the limiting accuracy of frequency measurements since the UHF oscillator has a short term stability of about 1 part in 10^6 or about 1/3 of a kilocycle.

F. Oxygen Ionization Experiments

Between August 28 and September 8 a series of ionization experiments on oxygen were made. The experimental conditions were different on different days but remained constant during any given day. Table 1 lists the experimental conditions prevailing for each experimental run. Cavity frequency shift, electron beam current, and oxygen pressure were measured. Two typical plots of cavity frequency shift versus electron beam current are shown in Figures 5 and 6; Figure 5 is at a "low" pressure, 0.37 mm, and Figure 6 is at a higher pressure, 1.2 mm. oxygen from a Matheson Company high pressure cylinder was used for all of the experiments; the purity of this gas is 99.5%, with 0.45% argon (max.) and 0.05% nitrogen (max.).

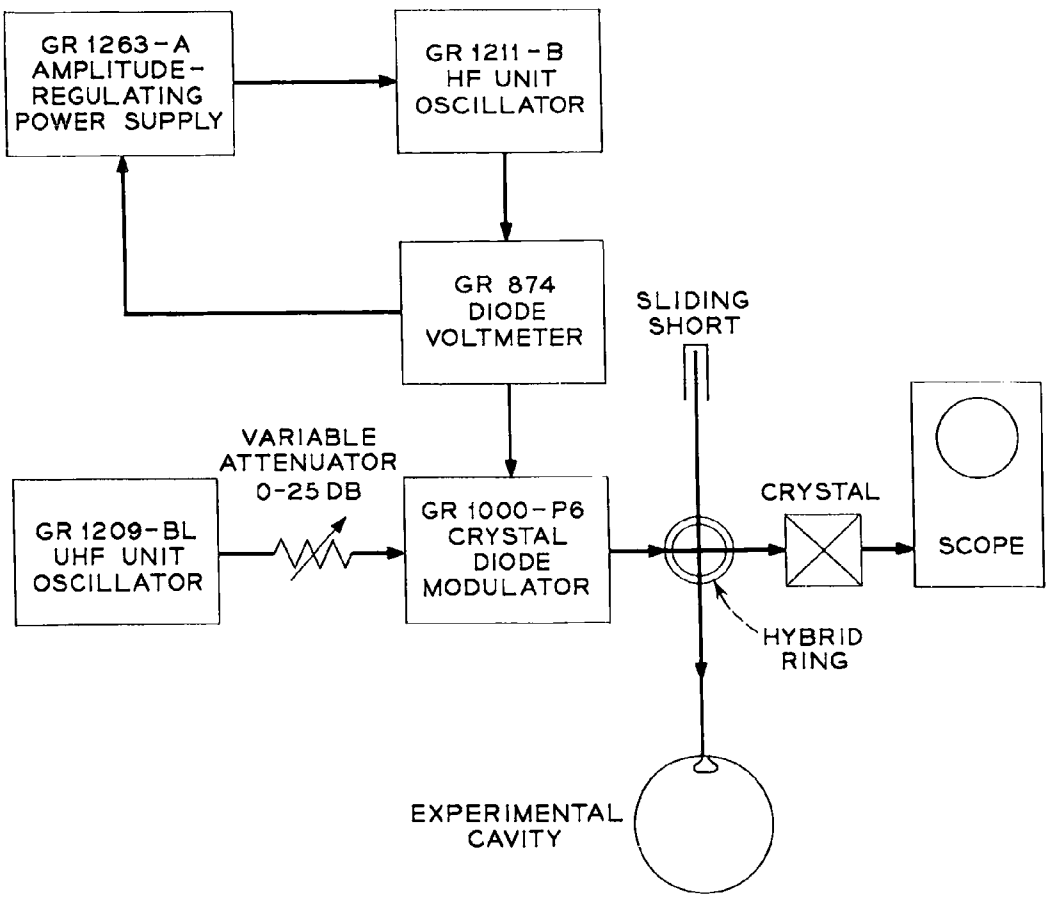

FIGURE 4
MICROWAVE CIRCUIT

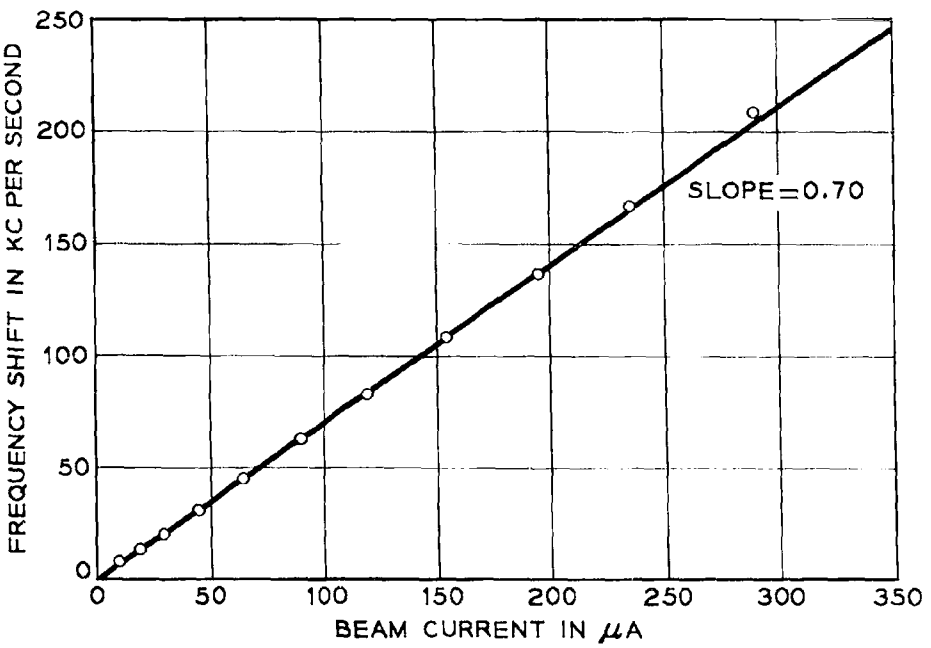

FIGURE 5
FREQUENCY SHIFT VERSUS BEAM CURRENT
O_2 AT 1.2 MM [SEPT. 6]

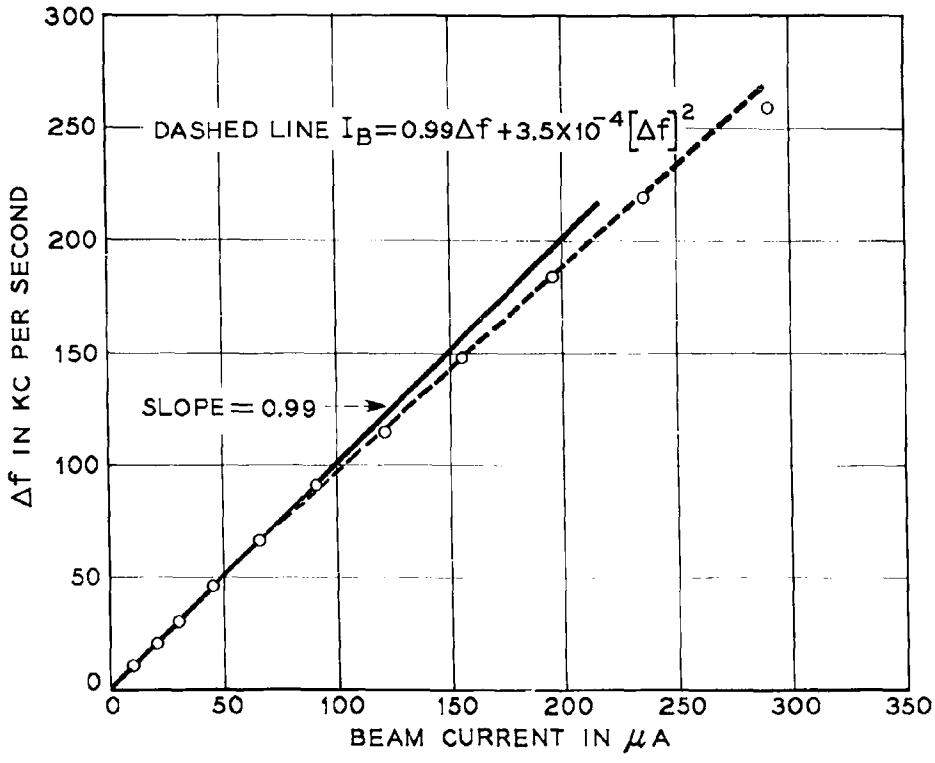

FIGURE 6
FREQUENCY SHIFT VERSUS BEAM CURRENT
O_2 AT 0.37 MM [SEPT. 6]

TABLE I. - OXYGEN EXPERIMENTS

Date	Pressure mm of Hg.	Previous Condition of Cavity 1.)	RF Circuit 2.)	Beam Current Measurement	Low Current Slope kcps/μa 3.)
8/28	2.0	Forepumped $\approx 10\mu$	Old	Total Current Meter	0.343
"	1.4	2 mm O_2	"	" "	0.469
"	1.1	1.4 mm O_2	"	" "	0.606
8/30	10	Forepumped $\approx 10\mu$	New	" "	0.126
9/5	1.2	Forepumped $\approx 10\mu$	"	Pentode dial	0.642
"	0.45	1.2 mm O_2	"	" "	1.10
9/6	1.2	Diffusion pumped $< 1\mu$	"	" "	0.70
"	0.74	1.2 mm O_2	"	" "	0.77
"	0.57	0.74 mm O_2	"	" "	0.90
"	0.37	0.57 mm O_2	"	" "	1.01
"	0.15	0.37 mm O_2	"	" "	0.962
9/7	5.12	Diffusion pumped $< 1\mu$	"	" "	0.264
"	4.0	5.12 mm O_2	"	" "	0.331
"	2.9	4.0 mm O_2	"	" "	0.498
"	1.0	2.9 mm O_2	"	" "	0.79

Notes to Table 1

1.) One load of oxygen was used for each day's experiments. The cavity was pumped out and then filled to the desired high pressure. Each subsequent experiment that day was made at a lower pressure obtained by pumping on the oxygen until the desired lower pressure was reached.

2.) The notation "Old" and "New" rf circuit refers to the circuit explained in the Fourth Quarterly Report and the circuit put forth in this report (Figure 4) respectively.

3.) See Chapter III, Section A.

Two other experiments were made which have a direct bearing on the oxygen ionization measurements. One was an attempt to observe a frequency shift in an empty cavity as a function of the bombarding electron beam. No such shift was observable. In the second experiment the microwave power into the cavity was reduced by 15db while bombarding 1.1mm O_2 with 155 μamperes of electrons. The initial power into the cavity was about 5 microwatts. No change in frequency shift was observed.

The first of these two experiments was made in order to determine if the electron beam heated the cavity walls sufficiently to produce gas which would contribute to the ionization measurements. An electron beam of 500 μamperes produced an unobservable amount of ionization in an empty cavity (pressure less than one micron).

The second experiment was made in order to determine if the rf power was perturbing the ionization measurement to the extent that the equilibrium ionization in the cavity was a function of the probing rf power. No such effect was noted for powers in the range of 5 microwatts to 0.1 microwatts, which is the range of powers used in all of the experiments reported.

G. Air Ionization Experiments

A series of air experiments was also tried during this quarter. They were made under the same conditions as the oxygen experiments, but did not yield reproducible results possibly because air from the room was used rather than from a standard source. Table 2 lists the experimental conditions prevailing for each experimental run. Figure 7 is a typical plot of cavity frequency shift versus electron beam current.

TABLE II. - AIR EXPERIMENTS

Date	Pressure mm. of Hg.	Previous Condition of Cavity	RF Circuit	Beam Current Measurement	Air Pre-Conditioning
8/28	5.0	Forepumped $\approx 10\mu$	Old	Total Current Meter	None
"	1.5	5 mm air	"	" "	"
"	1.0	1.5 mm air	"	" "	"
"	0.63	1.0 mm air	"	" "	"
9/4	1.0	Forepumped $\approx 10\mu$	New	Pentode Dial	Passed through liquid N_2 cold trap.
"	0.21	1.0 mm air	"	" "	" "
"	0.10	0.21 mm air	"	" "	" "
"	0.053	0.10 mm air	"	" "	" "
9/5	2.3	Forepumped $\approx 10\mu$	"	" "	" "
"	1.5	2.3 mm air	"	" "	" "
"	0.85	1.5 mm air	"	" "	" "
9/17	0.67	Diffusion pumped $< 1\mu$	"	" "	Held in liquid N_2 cold trap for 5 minutes.
"	0.48	0.67 mm air	"	" "	" "
"	1.0	0.48 mm air	"	" "	" "
9/18	9.6	Diffusion pumped $< 1\mu$	"	" "	" "
"	7.45	9.6 mm air	"	" "	" "
"	5.65	7.45 mm air	"	" "	" "

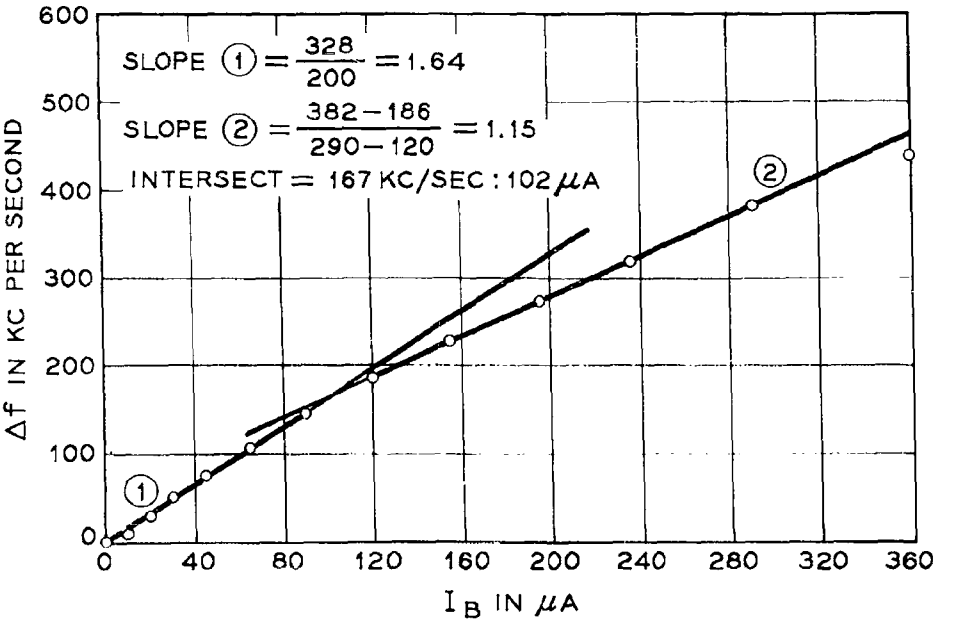

FIGURE 7
FREQUENCY SHIFT VERSUS BEAM CURRENT
AIR AT 0.21 MM [SEPT. 4]

III. DISCUSSION OF PRELIMINARY RESULTS

In this chapter the data obtained in the preliminary measurements will be studied to determine what they reveal about the experimental procedure, the operation of the equipment, and the processes occuring in the gases. To do this realistically, we must remember that the purity of these gases is characteristically worse than 1000 parts per million, which could well affect the types and rates of the atomic processes observed. In addition, there are uncertainties connected with the stability of the beam current calibration and other experimental quantities, which will be estimated in this section. In view of these uncertainties, any numerical values for reaction coefficients must be considered extremely tentative, and will only serve as indicators of the success of future equipment and procedural modifications to improve the measurements.

A. General Features of the Data

In both room air and cylinder oxygen, the frequency shifts observed in the gas-filled cavity are linear with accelerator beam current at sufficiently low currents. The slope of this linear region is reproducible, from day to day and gas load to gas load, to within about ±30%. (Some of this uncertainty must be attributed to drifts in the beam current calibration, so the actual gas behavior may be somewhat more reproducible than this.) The behavior of the data at higher currents is quite different in the two gases, however. In oxygen, the frequency shifts at high currents lie below the extrapolated straight-line fit to the low current data, on a smooth curve. In at least one measurement, all data can be fitted by the expression $I = a\Delta f + b(\Delta f)^2$. At the currents available to us (limited to about 400 μamp maximum due to outgassing from the aluminum beam collimater and foilholder), the low-current linear behavior characterizes the entire run in oxygen at pressures above about 1 mm Hg., the high-current curvature mentioned above manifesting itself only at pressures

lower than these. In air, on the other hand, the high current data lie on a straight line, of smaller slope than the low-current data, which intercepts the low current data abruptly. This behavior was observed at all pressures at which air measurements were made. There is a slight suggestion that, as the experiments continued, the onset of this second slope moved toward higher currents, as though it were somehow connected with an impurity driven off the walls at high currents, which was slowly being cleaned up during prolonged irradiation.

The ionization for a given beam current is higher in air than in oxygen at the same pressure, by a factor of about four. This fact can be restated in the equivalent, but more pertinent, way that the electron removal rate in oxygen is four times larger than in air. Our failure to observe a second straight-line region in oxygen at higher beam currents may be due to the competition of this stronger attachment process with the high-current process seen in air, or it may in fact not occur in oxygen at all. To determine this it will be necessary to push the oxygen measurements to higher currents.

Since the bowing of the aluminum foil which forms one face of the cavity is quite sensitive to small pressure changes in the gas, the resonant frequency of the cavity in the absence of ionization can be strongly dependent on gas heating by the electron beam. Observations of the capacitance manometer during bombardment do not indicate pressure changes due to the beam, to within the sensitivity of the manometer (about 3%). Small frequency shifts in the cavity were observed at zero ionization, however, particularly at higher pressures, where gas heating is expected to be greatest. These shifts amounted to about 50 kcps or less, in keeping with pressure changes of the order of one percent. This requires a change in the gas temperature of about $3^{\circ}K$. This small temperature change should have negligible effect on reaction rates. Hence, a scheme for subtracting correctly the offset resonant frequency of the cavity without free electrons from the frequency with the gas ionized would compensate

for this effect and yield reliable data. During the present period this was accomplished by manually turning off the accelerator beam and measuring a zero-beam frequency as soon after a high-current irradiation as possible. There may be some short-time cooling of the hot cavity which is not detected in this way, which will be studied during the next period by a method to be described in the next chapter.

In most of the discussion to follow, the data will be characterized only by the slope of the Δf vs I_b curves at low I_b. The low-current slope seems to be the most prominent and reproducible feature of the present data, and should be directly related to a simple linear theory of the ionization phenomena. Some mention will be made of the "roll-off" at higher currents in oxygen in the discussion as well. The air data are not yet in good enough shape to include in the discussion at this time. To avoid cluttering the field with results which are still very uncertain and which might be inadvertently quoted out of context, we feel it desirable to avoid any inclusion of them here until more detailed analyses of them can be made.

B. Processes in Oxygen

A simple model was presented in the First Quarterly Report for oxygen, including only three-body recombination, ambi-polar diffusion, and beam ionization. According to this model, the low-ionization data should have the following behavior:

1. At high pressures the specific ionization (electron density per unit beam current) should vary as the reciprocal of gas pressure, due to the "equilibrium" between beam ionization ($\propto p$) and three-body attachment ($1/p^2$).

2. At low pressures the specific ionization should vary as p^2 if the removal process is ambi-polar diffusion, in the fundamental spatial mode and controlled by a single ionic species throughout the pressure range.

The slopes of the straight lines on the Δf *versus* I_b plots at low currents are tabulated in Figure 8, in units of kilocycles per second "corrected" frequency shift per microampere of beam current. (The data have all been multiplied by $(1 + \nu_c^2/\omega^2)$, where ν_c is taken as 1.35×10^8 p for oxygen [1] so that the slopes are directly proportional to n_e *versus* I_b.) Although at high pressures the slopes from each day's runs seem incompatible, the internal consistency of each day's set of data is good, and shows the 1/p dependence quite strongly. (As stated in the preceding chapter, only the data for September 6 and 7 were taken with the system prepumped by the diffusion pump to a pressure below 10^{-3} mm Hg prior to filling with the experimental gas. Hence, the data taken earlier than this probably have a factor of 10 or 20 higher impurity than the later data, which may account for the incompatibility.) At about 1 mm Hg, the slopes begin to trail off to values lower than those given by the 1/p dependence. Included on the plot are two straight lines, drawn to fit the two processes assumed for the simple oxygen model. At high pressures, a straight line is fit to three-body attachment with a decay frequency of $2.1 \times 10^{-30} N^2 [O_2] \text{Sec}^{-1}$, [2] or, in terms of gas pressure p, $3.15 \times 10^3 p^2$ Sec.$^{-1}$. The low pressure line is fit to ambipolar diffusion in the fundamental mode. It is assumed, for lack of better data, that the ion controlling the diffusion in oxygen would have $D_a p \approx 100$ for the electrons, ions, and gas in thermal equilibrium at 300°K. (Note that both numbers are different from those presented in the First Quarterly Report, the attachment coefficient being based on newer data, and a computational error having been found in the earlier calculation of the diffusion frequency.)

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(1) V. A. J. van Lint, E. G. Wicker, and D. L. Trueblood, Rept. No. TR59-43 (August 31, 1959), General Atomics Division of General Dynamics Corporation, San Diego, California (unpublished).

(2) A. V. Phelps and M. A. Biondi, Research Report 908-1902-R1, Westinghouse Research Laboratories, Pittsburgh, Pennsylvania (unpublished).

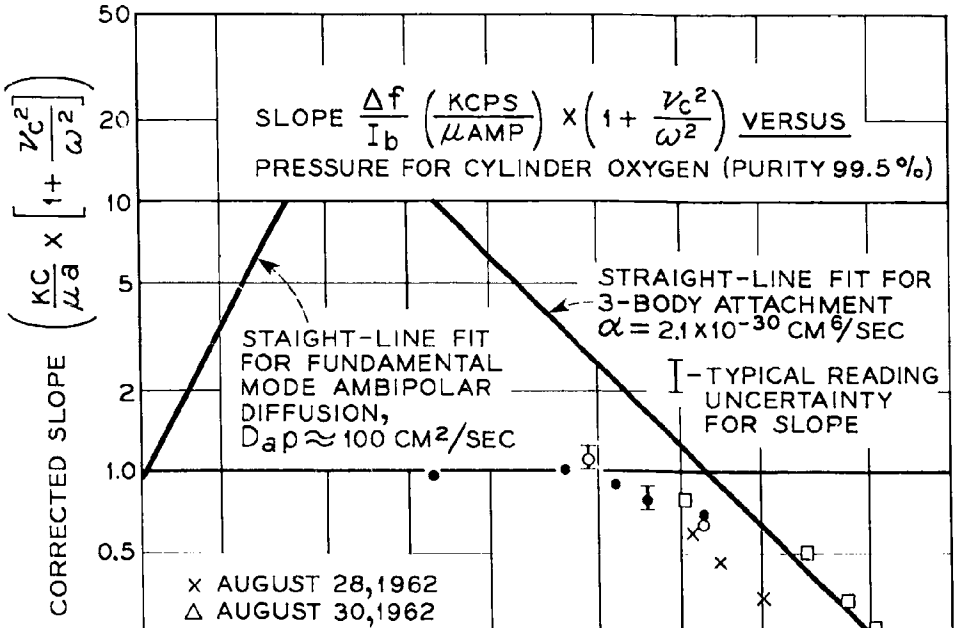

FIGURE 8
COMPILATION OF OXYGEN DATA

At pressures above 3 mm Hg, the data fit the theoretical curve drawn for three-body attachment quite well. In view of the uncertainties still remaining in the experiment, however, we must regard this fit as fortuitous. In fact, positive identification of the p^2 dependent electron removal process as three-body attachment must await mass spectrometric observation of the negative ion thus formed. For ease in discussion, however, we assume for the present discussion only, that the high pressure electron removal is dominated by three-body attachment of the electrons to neutral O_2 to form the negative molecular ion O_2^-, with a rate coefficient $\alpha = 2.1 \times 10^{-30}$ cm^6/sec.

At pressures lower than those for which the attachment seems to fit, the data indicate less specific ionization than the simple model predicts. If the process at low pressures were indeed one of diffusion, then either very high diffusion modes or very energetic electrons are involved. To account for the numerical values of the slopes at these pressures, a diffusion frequency approximately two orders of magnitude higher than that assumed for the model would be required. We are reluctant to ascribe this to high-mode diffusion, as a peculiar, very high index mode would have to be invoked. Somewhat more likely is the possibility of poor electron thermalization at the lower pressures, so that electron energies in excess of ambient can be expected. Here, however, a temperature of 2.5 volts would be required, which is not easy to maintain in a molecular gas against the competition from inelastic collisions. Nevertheless, this possibility cannot be ruled out for the present, at least until electron temperatures are measured in this pressure region. The ν_c measurements anticipated during the next quarter should cast some light on this.

Another possible explanation of the data below 1 mm Hg should be mentioned here. It has been observed[3] that the principle effect of impurities in oxygen is the introduction of an apparent two-body attachment process, that is, an attachment proportional to $N[O_2]$. This effect would not be visible at high pressures because of its dominance

(3) van Lint, Op.Cit.

by the p^2 process, and in fact, the 10 mm Hg run seems to "fit" the theoretical curve for 3-body attachment quite well despite its high impurity content (see previous chapters). At lower pressures, however, the electron loss would be due predominantly to this p-varying process; since the primary beam ionization also varies as p, the net electron density would be constant. The slopes should then vary with pressure as $(a + bp)^{-1}$. This, in fact, seems to describe the observations, although the data cover a pressure range which is too limited for verification. If, however, we accept this hypothesis, as well as the three-body attachment coefficient of Phelps et al, then the two-body attachment has a rate coefficient for these particular data of 1.6×10^{-17} cm^3/sec, or 6.2×10^{-1}/sec-mm Hg. In pure oxygen it is believed that the two-body attachment is a dissociative process, which has a threshold of 1.3 volts electron energy. Again, the interpretation must await measurements of ν_c at the lower pressures to determine T_e, and mass spectroscopic studies of the negative ions thus formed. Empirically, however, we can state that our results indicate an electron loss frequency $\nu_L n = 3.15 \times 10^3 p^2 n + 6.2 \times 10^{-1} pn$. If the two-body term is an impurity process, then further refinements in the vacuum technique and gas purity should reduce the apparent two-body coefficient.

C. Estimates of Experimental Uncertainties

At present, the measurement of frequency shifts in the resonant cavity is probably our most precise experimental technique. Measurements are reproducible to half a small division on the vernier dial of the modulation oscillator, which varies between about .35 and 3.5 kcps over the .5 to 5 Mcps range of the oscillator. For most measurements reported here, the uncertainty was about 1.5 kcps. A frequency shift of 10 kcps is thus accurate to about 2%. The measurement of a large number of frequency shifts as functions of beam current, and their subsequent straight-line averaging to obtain a slope reduces this error by a factor of the square root of the number of

measurements, so that Δf uncertainties contribute less than 1% to the uncertainty in the slope.

The beam current uncertainty is more difficult to estimate. From the limited information thus far available, it appears that the shape of the beam current versus pentode dial reading remains very nearly fixed from day to day, but that the entire curve slides along the pentode dial axis by about ± 0.5 divisions over a period of days. Because of the curvature in the calibration, this shift could have a marked effect on the low-current slopes. At higher currents this is not so serious, but the slopes at low currents seem to have an uncertainty of about ±15%, to judge from the reproducibility of runs made at a given pressure over a period of several days. This uncertainty in beam current will be greatly reduced when the new switching technique, described in the next chapter, is put into operation. With the data obtained during this report period, the choice of a straight line fit was about ±10% uncertain. As far as the present measurements are concerned, then, the empirically determined probable error in the slope is a little less than ±30%.

A source of error which cannot be estimated numerically at the present time deals with gas purity. As yet we have no means of measuring the impurity concentrations in the sample gas loads, if only to establish the reproducibility of sample composition. It is hoped that the addition of a mass spectrometer to the equipment, which is currently being contemplated for ion studies, will remove this difficulty, and permit monitoring of the initial gaseous impurities, as well as any radiation-induced species formed during bombardment.

IV. PLANS FOR NEXT QUARTER

The measurements reported in earlier sections were made to study the functioning of the experimental equipment. Several minor difficulties were, in fact, discovered, and will be remedied during the next quarter.

At high pressures, a problem is encountered with heating, presumably of both gas and aluminum foil, by the electron beam. This heating, while too small to be of importance to the rates of fundamental processes occuring in the gas, does shift the cold resonant frequency of the cavity (that is, the resonant frequency in the absence of ionization) downward, thus changing the apparent Δf. This can be counteracted by a technique for rapidly turning off the beam and measuring the cold resonant frequency as soon thereafter as possible. This will be accomplished by the magnetic beam switch shown in Figure 9. Rapid magnetic deflection of the beam will save about 30 seconds over manual turn-off, and permit zero-ionization measurements to be made very soon after the beam is turned off. The equipment is being designed to permit its eventual use as a rapid beam switch for transient afterglow studies.

The measurement of electron current actually striking the cavity must be made in a way which can be performed during experiments. During the next quarter, the cavity will be isolated from ground, and used as a Faraday Cup. Accurate measurements will be made of beam current.

During the quarter, the following additional improvements will be made. The vacuum system will be repaired and cleaned, and diffusion pumps filled with Convalex-10 (an improved oil for ultra-high vacuum). The gas pressure measurements will be extended down to 10^{-3} mm Hg with a Mc Lead gauge. Q measurements will be begun during the quarter

to determine electron collision frequencies and temperatures. A series of measurements will then be made of electron density and Q's in reagent grade O_2, N_2, and N_2-O_2 mixtures over the entire available pressure range.

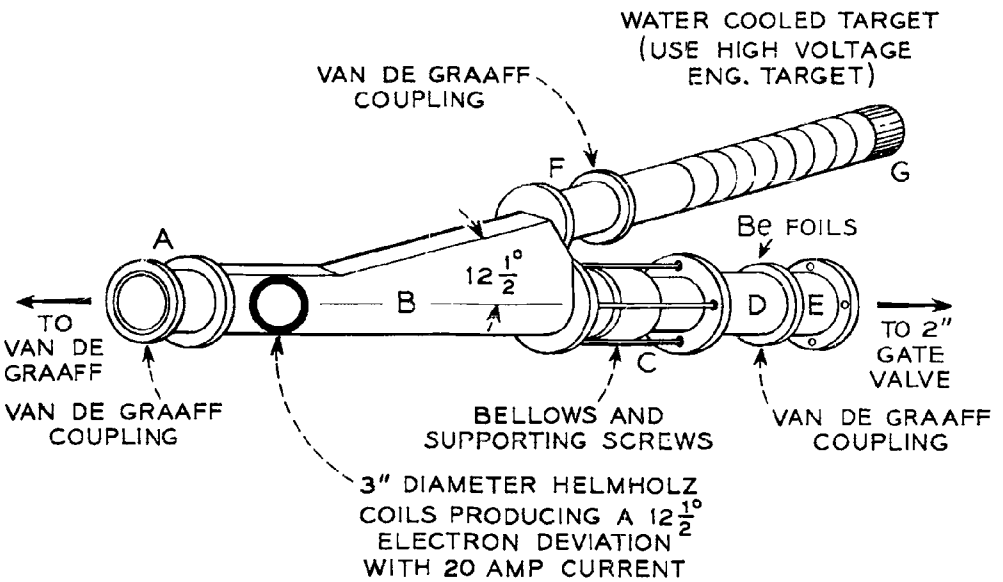

FIGURE 9
BEAM SWITCHER AND DIFFUSER

Make all tubing and box out of brass (except for water cooled target which is stainless steel), using Van de Graaff couplings throughout.

Parts

A - Short length of 2.375", 2" Nom. Brass Pipe with a Van de Graaff coupling at one end and a "Box" adaptor at the other.

B - Box of $1\frac{1}{2}$" width with sidearm set at angle of $12\frac{1}{2}^{\circ}$ to straight through path.

C - Bellows attached to box and supported by adjustable screws holding Brass pipe D (same OD as A).

D - 2.375", 2" Nom. Pipe (Brass) with a Van de Graaff coupling at one end.

E - Be foil holder, with Van de Graaff coupling at one end and flange to fit 2" Gate valve at other end.

F - Short length of 2.375", 2" Nom. Brass Pipe with Van de Graaff coupling at one end and a "Box" adaptor at other.

G - Water cooled target of stainless steel, 12" long. (Furnished)

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